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THE RELATIONSHIP OF SELECTED OBJECTIVE FACTORS TO TEAM SUCCESS IN COLLEGE FOOTBALL

BY

LAWRENCE EDWARD LANGEMO

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A thesis submitted
in partial fulfillment of the requirements
for the degree Master of Science, Major
in Physical Education, South
Dakota State University

1974

THE RELATIONSHIP OF SELECTED OBJECTIVE FACTORS

TO TEAM SUCCESS IN COLLEGE FOOTBALL

This thesis is approved as a creditable and independent investigation by a candidate for the degree, Master of Science, and is acceptable for meeting the thesis requirements for this degree. Acceptance of this thesis does not imply that the conclusions reached by the candidate are necessarily the conclusions of the major department.

Thesis Advisor Date

Head, and Recreation Department Date

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CHAPTER I

INTRODUCTION

Significance of the Study

American football has undergone many significant changes since its first recorded game between Rutgers and Princeton in 1869.[1] It has been proclaimed by many to be the number one spectator sport in the United States over the last decade. The main objective of football is to win. Winning is accomplished by one group of eleven players moving a football across a goal line at one end of a field, or moving it close enough to the goal posts to kick the ball over the crossbar and between the uprights.[2] If one group of eleven players does this and prevents the other team from doing it as often, that group will win. Why is it that one team has the ability to move the football across the goal line more often than an opponent of equal ability?

The methods and factors involved in winning football games have been analyzed in many different ways. Football coaches, sports broadcasters, and sportswriters are constantly bombarding their teams and fans with statistics, explanations and ideas of the most crucial factors and phases involved in winning football games.

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[1]Knute Rockne, Coaching ,(New York: Devin-Adair Company, 1939), p. 59-62.

[2]Leonard Koppett, The New York Times Guide to Spectator Sports, (New York: Quadrangle Books, Inc., 1971), p. 39.

What are really the most important factors in winning football? Are they yards gained, interceptions, fumbles lost or are they pass completions, field goal percentage, third downs converted to first downs? The direction of this study was to investigate the relationship of selected objective factors of playing football to the winning of games.

It is hoped that this study will be of significance to the football coaching profession. It should give the coach some evidence as to what factors are most related to winning games. Also there could be intense concentration placed on those factors in practice sessions and less concentration on factors which are not significantly related to team success.

Statement of the Problem

The purpose of this investigation was to study the relationship between team success in North Central Intercollegiate Athletic Conference football games and sixty-eight selected objective factors occurring in those games.

Hypotheses

1. There is no significant relationship between any of the sixty-eight independent variables and team success in North Central Conference football.

2. A regression equation to significantly predict team success from the independent variables cannot be developed.

Limitations and Delimitations

1. Only data obtained from games played between North Central Conference football teams were used in this study. These teams are South Dakota State University, the University of South Dakota, Augustana College of Sioux Falls, Mankato State College, North Dakota State University, the University of North Dakota, the University of Northern Iowa, and Morningside College of Sioux City.

2. Statistics collected from games played between North Central Conference football teams during the 1972 and 1973 seasons were investigated. However, statistics of the home games of Mankato State College and Morningside College could not be obtained due to circumstances beyond the control of the investigator. Therefore, a total of 42 games and 84 observations of individual teams were included for data purposes.

3. Only sixty-eight independent variables were selected to be investigated.

4. Team success was measured by three dependent variables; point spread between teams, total points scored by a team, and winning percentage over the two North Central Conference seasons that were investigated.

Definitions of Terms

For reader understanding the following terms are defined.

Point spread. Point spread is defined as the numerical difference between the points scored by the two teams. A plus value indicates a winning team's point spread and a minus value the losing team's spread.

Winning percentage. The number of conference games won by a team during the 1972 and 1973 seasons divided by the number of conference games played multiplied by 100.

Total yards gained. The number of yards gained by means of rushing and passing by a team.

Percentage of game's total. The amount of any one selected factor of the game possessed by one team divided by the sum total of that factor possessed by both teams multiplied by 100. Example: Team A gains a total of 300 yards rushing and team B gains a total of 200 yards rushing. Sum total rushing of both team A and team B for the game was 500 yards. Formula to obtain percentage of game's total: 300/500 = .60 x 100 = 60% of game's total rushing. This indicates that team A had sixty percent of the game's total rushing yardage.

Average yards gained per kick-off return. The total yards gained from their own goal line by the receiving team after a kick-off. This total is divided by the number of kick-offs returned to give an average. The twenty yards gained after a touchback is included.

Average yards gained per punt return. The total yards gained from the point the punt is received to the point the receiver is downed divided by the number of punts made by the opposing team. The twenty yards gained on a touchback after the ball has been punted into the end zone is included.

Number of offensive plays run. The number of plays from scrimmage run by a team. This includes only runs and passes.

Point-after-touchdown (PAT). The opportunity to score one point (by kicking the ball through the goal posts) or two points (by running or completing a forward pass over the goal line). This opportunity is presented to a team after each touchdown scored. The symbol PAT will be used throughout the study to indicate point-after-touchdown.

Independent and dependent variables. Roscoe defines independent and dependent variables in terms of a cause and effect relationship. Variations in the independent variable are presumed to cause variations in the dependent variable. In the prediction situation, the score on the independent variable is used to predict the score on the dependent variable.[3]

In this study the independent variables were the sixty-eight objective factors investigated. The dependent variables were the three measurements of winning or team success.

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[3]John T. Roscoe, Fundamental Research Statistics for the Behavioral Sciences, (New York: Holt, Rinehart, and Winston, Inc., 1969), p. 110-111.

CHAPTER II

REVIEW OF RELATED LITERATURE

Limited research has been completed in the area of predicting or correlating team success in football with statistical factors occurring in the games. However, studies have been completed in football and two other major team sports, baseball and basketball, which predict and correlate individual and team success from objective factors. The review provided information about design and procedures for completing this study and aided in the analysis and interpretation of results.

Related Research Completed in Baseball

Knutson correlated rankings for annual batting, earned run and fielding averages, slugging percentage, home runs, and runs scored with final standing in the American and National Professional Baseball Leagues. Pearson product-moment correlations were run for each factor with final standing over a five year period (1961-1965). The earned run average and runs scored had the highest correlation with league standing in both leagues for all seasons. The correlation for home runs with league standing was not significant at the .05 level of confidence for either league during any season. Knutson concluded that aspects of play dealing with hitting were more significant in the National League and defensive aspects were more significant in the American League.[1]

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[1]James A. Knutson, "The Relationship of Selected Statistics to Team Standings in Major League Baseball, 1961-1965", (Unpublished Master's thesis, University of Washington, Seattle, Washington, 1966), p. 86.

Long completed a study using 47 subjects from three Illinois high school baseball teams by administering a questionnaire to measure team cohesiveness and employing three performance tests to measure skills in baseball ability. Hitting ability was obtained from season batting averages. Linear regression analysis was used to determine which factor, cohesion or skills, had the greater contribution to team success. When deleted from the full model, cohesion had a greater power of prediction than did skills. The skill measure, throwing for accuracy, had a greater power in predicting team success than skills concerning throwing for distance, speed, and hitting ability.[2]

Stam studied the relationship of errors to runs scored in high school baseball. Data were obtained from the scorebooks of a Massachusetts high school baseball team for the years 1965 to 1970 inclusive. During this time period 107 games were played. Stam concluded, using percentage analysis and the contingency coefficient, that there was a low to moderate relationship between winning and number of errors committed; as the number of errors decreases, the chance of winning increases.[3]

Edlund completed a study to investigate the relationship between right grip strength, left grip strength, right wrist strength, left wrist strength, trunk strength, kinesthetic perception, peripheral vision, depth perception, reaction time, speed of movement time,

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[2]Grant H. Long, "Cohesion: A Predictor of Team Success," (Unpublished Masters thesis, Southern Illinois University, Carbondale, Illinois, 1972), p. 40-67.

[3]Neil J. Stam, "The Relationship of Errors to Runs Scored in High School Baseball," (Unpublished Masters thesis, Springfield College, Springfield, Massachusetts, 1972), p. 25-30.

hand-eye coordination, agility and leg power with the ability of an individual to hit a baseball. He also attempted to develop a regression equation from the independent variables which could be used to predict hitting success.[4]

Edlund concluded the following: 1) Only right grip strength related significantly to hitting against the pitching machine indoors. 2) Hitting ability against the pitching machine indoors can be significantly predicted from a combination of three variables including right grip strength, kinesthetic perception, and left wrist strength. 3) Hitting ability against live pitching indoors cannot be predicted with significance from the variables investigated. Also, there was no significant relationship between the independent variables and hitting ability against live pitching indoors. 4) Hitting ability against opponents in game situations cannot be predicted with significance from the combination of variables used nor was there a significant relationship between the independent variables and hitting ability in game situations. 5) Although not statistically significant, the magnitude of the multiple correlations (R = .928) made it apparent that hitting ability against opponents in game situations can be

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[4]Larry L. Edlund, "The Relationship of Hitting Ability in Baseball to Selected Anatomical Measurements and Motor Responses," (Unpublished Master's thesis, South Dakota State University, Brookings, South Dakota, 1971), p. 2.

predicted with reasonable accuracy. It can be practically done by using the four variables of kinesthetic perception (arm raise), speed of movement time, trunk strength and left wrist strength.[5]

Related Research Completed in Basketball

Mouw studied certain objective factors in high school basketball in order to determine their relationship to team success as measured in terms of winning. Statistics were gathered on certain factors in an average AAAA classification league in California. A major portion of the study dealt with comparing winning team performances with losing team performances. The "t" test was used to determine if the differences in the means in each category were statistically significant. The conclusions were that the differences in the number of successful field goals and field goal percentage were significant to winning at the .01 level of confidence. Also, the differences in the number of total rebounds, number of defensive rebounds, number of offensive rebounds, number of free throws attempted, number of free throws made, and fouls committed were significant at the .05 level.[6]

Peterson studied twenty-eight Northwestern Missouri Class A and B high school basketball teams by analyzing measurable factors such as free throws, field goal shooting, ball handling errors, jump balls,

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[5]Edlund, p. 68-69.

[6]Robert Mouw, "An Analysis of Factors Related to Basketball Success," (Unpublished Master's thesis, Long Beach State College, Long Beach, California, 1971), p. 1-2.

total players used, personal fouls and rebounding in relationship to team success. Team success was defined as winning more than fifty percent of games played. t-ratios for each factor were then computed to see if there was a significant difference between the totals of winning and losing teams in these categories. It was found that there was a significant difference between the winning and losing Class B teams in free throws. Also, all winning teams tended to take more shots in closer, get more rebounds, commit fewer fouls, and make a higher percentage of their shots than do losing teams. However, these factors were not significant and, therefore, may be due to chance.[7]

Finanger completed a study on the relationship of rebounding, free throw shooting and foul location to high school basketball performance. The data were taken from seven Wisconsin high school home basketball games and eleven games in the Wisconsin Interscholastic Athletic Association State High School Basketball tournament. t-ratio comparisons were made between winners and losers on rebound location, type of rebound, foul location and shooting percentages. The winning teams controlled both the offensive and defensive rebounds. The defensive team obtained the majority of missed free throws. Defensive fouls greatly outnumbered the offensive fouls and the percentage of fouls called in the second half was greater than those called in the

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[7]Herbert Donald Peterson, "A Study of Certain Objective Factors in High School Basketball and Their Relationship to Team Success," (Unpublished Master's thesis, University of Indiana, Bloomington, Indiana, 1952), p. 115-122.

first half. The winning team attempted more free throws, scored more free throws, and committed fewer fouls than the losing teams.[8]

Snyder investigated proficiency in performing four selected physical skills as a basis for predicting individual basketball playing ability. Four skill tests not involving ball handling ability were given as a pretest. After three weeks instruction, the Johnson Basketball Ability Test was given and performance was scored during scrimmage. Pearson product-moment correlations between the skill tests and Johnson test were negative and correlations between them and scrimmage performance were low. The highest correlation (.526) was between the Johnson Test and scrimmage performance.[9]

Strain attempted to predict future player success from sophomore game statistics in basketball. From the years 1961 to 1968 inclusive, game statistics on thirty juniors and twenty-one seniors of Rapid City, South Dakota, high school basketball varsity teams who had completed the sophomore, junior, and senior basketball seasons furnished the data for the formulization of three predictive equations from the relationship of individual sophomore game statistics and varsity point production. Regression analysis statistics were employed to analyze the data.

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[8]Kenton E. Finanger, "The Relationship of Rebounding, Free Throw Shooting, and Foul Location to High School Basketball Performance," (Unpublished Master's thesis, University of Wisconsin, Madison, Wisconsin, 1957), p. 143-150.

[9]John Jay Snyder, "An Experiment Involving Proficiency in Performing Four Selected Physical Skills as a Basis for Predicting Basketball Playing Ability," (Unpublished Masters thesis, University of Washington, Seattle, Washington, 1964), p. 61-65.

Regression equations were developed to predict the point production of three classifications of varsity basketball players from their sophomore game statistics. The classifications were juniors, seniors, and a combination of junior-senior players. The most significant predictor of the three equations with regard to estimating varsity point production was the junior-senior classification.[10]

Related Research Completed in Football

Allsen and Foster completed a study that directly researched the area of correlating factors to team success in football. They state

> "Many coaches and experts have opinions about ball control and its relationship to won-loss records, but a search of the literature revealed that little or no scientific research has been compiled in this area."[11]

The purpose of their study was to determine the relationship that existed between the won-loss record and five selected elements. Eight high school and eight college games were charted and data were collected on five elements: (1) running plays, (2) passing plays, (3) total number of plays, (4) first downs, and (5) time of actual ball control.[12]

The procedure that Allsen and Foster used to analyze their data was as follows.

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[10]David Ford Strain, "Predicting Future High School Basketball Player Success as Measured by Estimated Varsity Game Point Production from Individual Sophomore Game Statistics," (Unpublished Masters thesis, South Dakota State University, Brookings, South Dakota, 1969), p. 40-43.

[11]P.E. Allsen and Joseph Foster, "Relationship Between Specific Elements and the Won-Loss Record," Athletic Journal, 50:36, May, 1970.

[12]Ibid., p. 36.

> "The data collected from the games were analyzed statistically through the use of the biserial correlation to determine relationships between won-loss and selected elements. Correlations were determined for the college games, high school games, and the total number of games. In order to determine the correlations for all of the games, the high school scores were multiplied by 1.23 to compensate for the time element of the high school score in comparison to the college score."[13]

The correlations between the won-loss record and selected variables were:

Running Plays	-	.990
Pass Plays	-	-.431
Total Plays	-	.878
First Downs	-	.790
Ball Control Time	-	.749 [14]

Allsen and Foster made the following summarizing conclusion from the results of their study.

> "This study would indicate that the team which runs the most plays and utilizes a running attack will in most cases emerge the winner. Actual ball control time may be a factor in winning but is less important than the previously mentioned two items."[15]

Olmstead analyzed the try-for-point as a determining factor in winning or losing football games. A questionnaire was sent to winning and losing high school football coaches in the Sacramento Valley area

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[13]Allsen and Foster, p. 36-37.

[14]Ibid., p. 37.

[15]Ibid., p. 92.

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and observations were made of percentages of PAT's per try. It was found that football teams with winning records were more successful on try-for-points than teams with average and losing records.[16]

Price studied relationships of college coaches' ranking of individual ability with football players' strength, speed, and agility. Pearson product-moment correlations were computed between the objective test scores and coaches' subjective evaluations. It was concluded that arm strength and agility did not relate significantly to football ability, total strength and total T-score were moderately related to football ability, and leg strength and speed were significantly related to football ability.[17]

Rydalch attempted to predict player success from identifying and analyzing biographical factors. Data were collected on 812 football players from seventeen junior colleges located in eight states. Head football coaches rated their own individual players. The ratings of the coaches were then analyzed by multiple correlation and regression analysis. Twelve independent variables were significantly related to

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[16]David M. Olmstead, "An Analysis on the Try-For-Point as a Determining Factor in Winning or Losing Football Games in the Sacramento Valley Area," (Unpublished Master's thesis, Sacramento State College, Sacramento, California, 1968), p. 70-74.

[17]Gary N. Price, "The Relationship of College Football Players' Strength, Speed, and Agility to the Coaches' Rankings of Ability," (Unpublished Master's thesis, University of Washington, Seattle, Washington, 1967), p. 44-51.

individual football success. Of the twelve variables, six factors, honors, speed, weight, team record in high school, height, and size of high school, were selected as those variables with the highest relationship to success.[18]

Vis studied the relationship of forward pass catching ability in football with certain anatomical measurements and motor responses. Twenty-three subjects were tested on eleven independent variables which were thought to be related to pass catching ability. The criterion was measured as the number of receptions out of 120 passes on eight different patterns. A multiple correlation and regression statistical procedure was employed to analyze the data. Several independent variables were significantly related to the criterion and significant regression equations were developed to predict the criterion.[19]

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[18]Donald D. Rydalch, "A Study to Identify and Analyze Biographical Factors Which Predict Player Success in Junior College Football," (Unpublished Doctoral dissertation, Brigham Young University, Provo, Utah, 1971), p. 88-100.

[19]Marlin P. Vis, "The Relationship of Forward Pass Catching Ability in Football and Selected Anatomical Motor Responses," (Unpublished Master's thesis, South Dakota State University, Brookings, South Dakota, 1971), p. 35-60.

CHAPTER III

METHODS AND PROCEDURES

Study Organization and Source of the Data

The purpose of this study was to determine the relationship between sixty-eight independent variables involved in the game of football with three dependent variables of team success in college football. Through a review of the literature, consultation with coaches, and from personal experience, the sixty-eight independent variables and three dependent variables were established for investigation. The three measurements of success were: 1) point spread between teams; 2) total points scored by a team; and 3) winning percentage over the two North Central Conference seasons being investigated. The sixty-eight independent variables were classified into nine categories as follows: 1) home field factor; 2) total factors (including rushing and passing combined); 3) rushing factors; 4) passing factors; 5) kicking and kick return factors; 6) scoring factors; 7) turnover factors (fumbles and interceptions); 8) penalty factors and 9) ball control factors.

In consultation with Dave Martin, Sports Information Director at South Dakota State University, a letter requesting a copy of the game statistics and play-by-play sheet for each North Central Conference home football game played during the 1972 and 1973 seasons was sent to the Sports Information Directors of each college in the North Central Conference. (A copy of the letter appears in Appendix A and examples of a game statistics and play-by-play sheet appear in Appendix B.)

The eight colleges contacted for data purposes were South Dakota State University, University of South Dakota, Augustana College, North Dakota State University, University of North Dakota, University of Northern Iowa, Mankato State College, and Morningside College.

Data were obtained and compiled on the information received concerning the sixty-eight independent variables and three dependent variables. Follow-up letters were sent and personal telephone calls were made by Dave Martin to Sports Information Directors who failed to send the information requested. The necessary data were received from all institutions with the exception of Morningside College and Mankato State College. The new Sports Information Director at Morningside indicated that the necessary information was not on file and no correspondence was received from the Mankato State Sports Information Director.

Collection of Data

The independent variables (X's) on which data were collected in each category were:

I. Home field factor

X_1 - Home field (1 = home, 2 = away)

The popular belief is that a team will be at an advantage if it plays on its own field, in familiar surroundings and in front of its own fans.

II. Total yardage factors

X_2 - Total yards gained

X_3 - Total yards gained by opponent

X_4 - Percentage of games' total yards gained

Luptak states, in speaking of game statistics, that total yardage factors are critical to the outcome of games.[1]

III. Rushing factors

X_5 - Total yards rushing

X_6 - Total yards rushing by opponent

X_7 - Percentage of game's total rushing yards

X_8 - Number of rushing attempts

X_9 - Number of rushing attempts made by opponent

X_{10} - Average yards gained per rushing attempt

X_{11} - Average yards gained per rushing attempt by opponent

Rushing has been considered by many to be the essence of football. The single wing and wishbone offenses, for example, often rely almost solely on rushing for their success. Allsen and Foster, in their study, report a biserial correlation of .99 between number of rushing plays and winning.[2]

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[1]Andrew Luptak, "Taking Football Statistics," Athletic Journal, 53:58, February, 1973.

[2]P. E. Allsen and Joseph Foster, "Relationship Between Specific Elements and Won-Loss Record," Athletic Journal, 50:36, May, 1970.

Deromedi made this statement about his team.

> "Basically ours is a running team. The forward pass is used only to open up the defense and take advantage of defenses which are designed to stop the running game. Specifically, the offensive philosophy stresses ball control through rushing."[3]

Luptak also included rushing totals as one of the six most important factors in a game.[4]

IV. Passing factors

X_{12} - Total yards passing

X_{13} - Total yards passing by opponent

X_{14} - Percentage of game's total passing yards

X_{15} - Number of passing attempts

X_{16} - Number of passing attempts by opponent

X_{17} - Number of passes completed

X_{18} - Number of passes completed by opponent

X_{19} - Percentage of passes completed

X_{20} - Percentage of passes completed by opponent

X_{21} - Average yards gained per pass attempt

X_{22} - Average yards gained per pass attempt by opponent

X_{23} - Average yards gained per pass completion

X_{24} - Average yards gained per pass completion by opponent

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[3]Herb Deromedi, "Offensive Line Techniques - A Part of Ball Control," Athletic Journal, 49:14, June, 1969.

[4]Luptak, p. 58.

The forward pass has been one of the reasons for revolutionizing the game of football. Rockne stated that the popularity of football is due "entirely to the open game, to the increase in the versatility of the offense, and to the perfection of the technique of the forward pass."[5]

Driscoll also supported the idea that the passing game is becoming increasingly important in football.[6] Luptak included passing totals as being important to the game also.[7]

V. Kicking and kick return factors

X_{25} - Average yards gained per kick-off return

X_{26} - Average yards gained per kick-off return by opponent

X_{27} - Average yards per punt

X_{28} - Average yards per punt by opponent

X_{29} - Average yards gained per punt return

X_{30} - Average yards gained per punt return by opponent

The kicking game or specialty team game as it has been called in pro football, has recently become recognized as being probably as critical to football success in many cases as are rushing and passing. Hansell, for example, included punt and kick-off returns among his eight situations critical to winning games.[8]

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[5]Knute Rockne, p. 59-62.

[6]Dave Driscoll, "Passing by the Numbers," Athletic Journal, 47:60-64, May, 1967.

[7]Luptak, p. 58.

[8]George A. Hansell, "Meeting the Eight Critical Game Situations," Scholastic Coach, 35:50, May, 1966.

Read and Read made this statement in regard to the importance of the punting phase of the game.

> "Successful teams are able to punt well. The results of many games can be attributed to sound punting, blocking and coverage."[9]

Sartore made the following statement about the kicking game in presenting a case for the significance of the kick-off return.

> "The kicking game is one of the most neglected phases of football, and while coaches try to correct this fault, emphasis is placed on the punt coverage and punt return. At the present time, the kick-off and the kick-off return are still basically neglected. Why should this be? The game can be broken wide open on the kick-off return just as it can be on the punt return."[10]

In conclusion, concerning the kicking game, Kahler says that words probably can't express the important role that "the foot" plays in present day football.[11]

VI. Scoring factors

X_{31} - Number of touchdowns scored

X_{32} - Number of touchdowns scored by opponent

X_{33} - Number of field goals made

X_{34} - Number of field goals made by opponent

X_{35} - Percentage of field goals made

X_{36} - Percentage of field goals made by opponent

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[9]Don Read and Len Read, "The Name of the Game," Athletic Journal, 47:38, May, 1967.

[10]Karl P. Sartore, "Returning the Kick-Off," Athletic Journal, 49:12, June, 1969.

[11]Robert W. Kahler, "Punt With a Purpose," Athletic Journal 49:12, June, 1969.

VI. Scoring Factors (continued)

X_{37} - Number of one point PAT's made

X_{38} - Number of one point PAT's made by opponent

X_{39} - Percentage of one point PAT's made

X_{40} - Percentage of one point PAT's made by opponent

X_{41} - Number of two point PAT's made

X_{42} - Number of two point PAT's made by opponent

X_{43} - Percentage of two point PAT's made

X_{44} - Percentage of two point PAT's made by opponent

X_{45} - Number of safeties made

X_{46} - Number of safeties made by opponent

This category seemingly relates significantly to winning since you must score points to win. However, some teams may not need touchdowns to win if they are able to kick field goals well. An example would be the wide spread use of the place kick in pro football in recent years. Field goals seem to be increasing in number and importance every year in the National Football League. Olmstead concluded that teams which were more successful on PAT attempts had the best chance of winning the closely contested ball game. It was also found in Olmstead's study that most coaches agreed on the value of the try-for-point, yet a majority practiced it only ten minutes a day, twice a week. [12] It may be important that a team is able to score two point conversions more readily than its opponent.

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[12]David M. Olmstead, "An Analysis on the Try-For-Point as a Determining Factor in Winning or Losing Football Games in the Sacramento Valley Area," (Unpublished Master's thesis, Sacramento State College, Sacramento, California, 1968), p. 74.

VII. Turnover factors

X_{47} - Number of interceptions made

X_{48} - Number of interceptions made by opponent

X_{49} - Average yards gained per interception return

X_{50} - Average yards gained per interception return by opponent

X_{51} - Number of fumble recoveries

X_{52} - Number of fumble recoveries by opponent

The number of turnovers in a game are often cited as being the turning point in football games. Fumble recoveries and pass interceptions are said to change a game around and would, therefore, be important to team success. Luptak included fumble recoveries as being important to the game and its statistics.[13] Also, Hansell listed fumbles and interceptions high on his list of eight critical game situations.[14]

King has this to say about interceptions.

> "Interceptions can and do win games. They can do more to break a team's morale than any one factor in football. They also can be and often are turning points in football games."[15]

VIII. Penalty factors

X_{53} - Number of penalties

X_{54} - Number of penalties against opponent

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[13]Luptak, p. 58.

[14]Hansell, p. 50.

[15]DeWayne King, Jericho: A Modern System of Pass Defense, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1963), p. 60-61.

VIII. Penalty factors (continued)

X_{55} - Total penalty yardage

X_{56} - Total penalty yardage against opponent

X_{57} - Percentage of game's total penalty yards against team

Penalties can hinder a team in its quest for success. Hansell includes penalties as a critical factor to winning games.[16] In his article on taking game statistics, Luptak says that penalties are one important factor to be recorded as significant to the game.[17]

IX. Ball control factors

X_{58} - Number of offensive plays run

X_{59} - Number of offensive plays run by opponent

X_{60} - Percentage of game's total offensive plays run by team

X_{61} - Number of first downs

X_{62} - Number of first downs by opponent

X_{63} - Average yards gained on first down plays

X_{64} - Average yards gained on first down plays by opponent

X_{65} - Number of third down situations converted

X_{66} - Number of third down situations that opponent converted

X_{67} - Percentage of third downs converted

X_{68} - Percentage of third downs that opponent converted

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[16]Hansell, p. 50.

[17]Luptak, p. 58.

Ball control is considered by many coaches as being necessary to achieve success. The theory being that if you have the ball, your opponent will not be able to score points. The various factors involving number of first downs converted, third down situations, and yardage gained on first down plays are reasons often cited by sports-casters and coaches as being keys to winning a game. Allsen and Foster found biserial correlations of .749 and .79 between ball control time and winning and between first downs and winning, respectively.[18]

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[18]Allsen and Foster, p. 36.

CHAPTER IV

ANALYSIS AND DISCUSSION OF RESULTS

Organization of the Data for Analysis

Procedures and a statistical design were developed to formulate an objective tool to aid in the prediction of team success in North Central Conference football. Sixty-eight independent variables were identified by the investigator as making possible contributions to team success. The dependent variables were three measurements of team success; point spread between teams, total points scored by a team, and winning percentage over the two North Central Conference seasons that were investigated. The raw data are found in Appendices C through H.

In order to be able to predict team success on the basis of the independent variables, a multiple correlation and regression statistical procedure was employed.[1] The procedure initially computed inter-correlations between the independent variables and correlations between the independent variables and each dependent variable. Multiple regression equations were then developed beginning with a one variable equation and adding an additional variable in each succeeding step in order to increase the accuracy of the prediction.

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[1]Robert G. Steel and James H. Torrie, Principles and Procedures of Statistics, (New York-Toronto-London: McGraw-Hill Book Company, Inc., 1960), p. 161-182.

For each step a multiple correlation, standard error of estimate, and variance accounted for in that step were computed. The use of an electronic computer facilitated the speed and accuracy of the statistical process.

Analysis of the Data and Discussion of Results

The data collected on all 68 independent variables and three dependent variables were initially analyzed. The results of this analysis indicated that variables from the scoring category contributed greatly to team success. For example, to predict point spread; of the first ten variables that appeared on the regression equation, eight were from the scoring category.

One of the main reasons for conducting this study was to provide the football coach with a practical tool to assist him in making decisions as to what factors contributed the most to team success. It was felt by the investigator that the initial analysis of all 68 independent variables did not accomplish this purpose. Therefore, in order to make the prediction more meaningful to the coach, the investigator consulted his advisor and the South Dakota State University Experiment Station Statistician and decided for the final analysis to analyze only 37 of the independent variables and the three dependent variables. This meant that 31 independent variables were eliminated in the final analysis. The following rationale was used in determining which variables were or were not included in the final analysis.

1) All variables in the scoring category were eliminated from the final analysis, since as was pointed out above, they dominated the regression equations and interfered with the other variables which were considered to be of more value to the coach. It was also felt that it was widely recognized that a team needs to score in order to win.

2) The variables which were thought to be the most meaningful to the coach were included. Because of this, the variables which concerned percentage of the game's total of a factor were eliminated. To tell a coach, for example, that his team must gain more yardage than his opponent is not as meaningful as telling him whether or not it is more important for his team to prevent the opponent from gaining many yards or to gain a great amount of yardage.

3) Some independent variables were concerned with the same statistic but approached the statistic in another direction. An example of this was in the penalty category where both number of penalties and penalty yardage covered the same factor of the game. In this case penalty yardage was retained because it was more continuous in nature.

4) The importance of the variable as shown in the initial analysis was also a consideration in making the choice. If an independent variable showed in the initial analysis to predict one of the team success variables, and if it was not a scoring variable, a duplication variable, or a percentage variable, it was included in the final analysis.

The 37 independent and three dependent variables included in the final analysis are presented in Table I along with means and standard deviations.

Zero order correlation analysis. The matrix of zero order correlations is presented in Table II. Two hundred and seventy-six of the 676 intercorrelations were significant at the .05 level of confidence. Twenty-eight of the 37 independent variables showed a significant correlation with point spread. Twenty-seven of the 37 independent variables correlated significantly with total points scored. Twenty-three of the 37 independent variables correlated significantly with winning percentage. Table III shows each of the independent variables which significantly correlated to any of the dependent variables.

The most meaningful measurement of team success was the point spread variable (Y_1) since it directly indicated the winning or losing of each game. The discussion of significant zero order correlations was therefore concerned mainly with the significant correlations of the independent variables with point spread.

Luptak stated that total yardage gained and stopping the opponent from gaining yardage are critical to the outcome of games.[2] The significant correlation of .70 between total yards gained and

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[2]Andrew Luptak, "Taking Football Statistics," Athletic Journal, 53:58, February, 1973.

TABLE I

MEANS AND STANDARD DEVIATIONS
OF SELECTED VARIABLES

Variables	Mean	Standard Deviation
Home Field Factor		
X_1 Home Field	1.50	.50
Total Factors		
X_2 Total Yards Gained	322.39	110.18
X_3 Total Yards Gained by Opponent	322.39	110.18
Rushing Factors		
X_5 Total Yards Rushing	188.75	93.10
X_6 Total Yards Rushing by Opponent	188.75	93.10
X_8 Number of Rushing Attempts	52.60	11.82
X_9 Number of Rushing Attempts by Opponent	52.60	11.82
X_{10} Average Yards Gained per Rushing Attempt	3.59	1.56
X_{11} Average Yards Gained per Rushing Attempt by Opponent	3.59	1.56
Passing Factors		
X_{12} Total Yards Passing	133.69	71.82
X_{13} Total Yards Passing by Opponent	133.69	71.82
X_{15} Number of Passing Attempts	21.43	8.34
X_{16} Number of Passing Attempts by Opponent	21.43	8.34
X_{19} Percentage of Passes Completed	42.24	13.79
X_{20} Percentage of Passes Completed by Opponent	42.24	13.79
X_{21} Average Yards Gained per Pass Attempt	6.53	3.15
X_{22} Average Yards Gained per Pass Attempt by Opponent	6.53	3.15
Kicking and Kick Return Factors		
X_{25} Average Yards Gained per Kickoff Return	27.80	9.57
X_{26} Average Yards Gained per Kickoff Return by Opponent	27.80	9.57
X_{27} Average Yards per Punt	35.43	5.60
X_{28} Average Yards per Punt by Opponent	35.43	5.60
X_{29} Average Yards Gained per Punt Return	4.41	4.17
X_{30} Average Yards Gained per Punt Return by Opponent	4.41	4.17

TABLE I (continued)

Variables	Mean	Standard Deviation
Turnover Factors		
X_{47} Number of Interceptions Made	1.67	1.60
X_{48} Number of Interceptions Made by Opponent	1.67	1.60
X_{51} Number of Fumble Recoveries	1.52	1.01
X_{52} Number of Fumble Recoveries by Opponent	1.52	1.01
Penalty Factors		
X_{55} Total Penalty Yardage	57.60	31.50
X_{56} Total Penalty Yardage Against Opponent	57.60	31.50
Ball Control Factors		
X_{58} Number of Offensive Plays Run	73.77	9.80
X_{59} Number of Offensive Plays Run by Opponent	73.77	9.80
X_{61} Number of First Downs	16.92	4.87
X_{62} Number of First Downs by Opponent	16.92	4.87
X_{63} Average Yards Gained on First Down Plays	4.05	1.58
X_{64} Average Yards Gained on First Down Plays by Opponent	4.05	1.58
X_{67} Percentage of Third Downs Converted	36.70	13.71
X_{68} Percentage of Third Downs Converted by Opponent	36.70	13.71
Measurements of Team Success		
Y_1 Point Spread	0	22.98
Y_2 Total Points Scored	20.67	14.09
Y_3 Winning Percentage	49.93	28.13

TABLE II

CORRELATION MATRIX*

Variables**	1	2	3	5	6	8	9	10	11
1	1.00	-.42	.42	-.39	.39	-.24	.24	-.25	.25
2		1.00	-.40	.76	-.47	.50	-.48	.56	-.47
3			1.00	-.47	.76	-.48	.50	-.46	.56
5				1.00	-.52	.75	-.55	.71	-.45
6					1.00	-.55	.75	-.45	.71
8						1.00	-.69	.37	-.35
9							1.00	-.35	.37
10								1.00	-.54
11									1.00
12									
13									
15									
16									
19									
20									
21									
22									
25									
26									
27									
28									
29									
30									
47									
48									
51									
52									
55									
56									
58									
59									
61									
62									
63									
64									
67									
68									
Y_1									
Y_2									
Y_3									

TABLE II (continued)

Variables**	12	13	15	16	19	20	21	22	25
1	-.12	.12	.20	-.20	-.17	.17	-.36	.36	-.03
2	.54	0	-.03	.33	.48	-.18	.65	-.24	-.01
3	0	.54	.33	-.03	-.18	.48	-.24	.65	-.10
5	-.13	-.05	-.50	.31	.16	-.23	.36	-.28	.04
6	-.05	-.13	.31	-.50	-.23	.16	-.28	.36	-.03
8	-.21	-.02	-.55	.33	.10	-.27	.32	-.35	-.14
9	-.02	-.21	.33	-.55	-.27	.10	-.35	.32	.19
10	-.05	-.13	-.33	.10	.13	-.20	.25	-.18	.08
11	-.13	-.05	.10	-.33	-.20	.18	-.18	.25	-.08
12	1.00	.06	.60	.09	.53	.02	.53	0	-.07
13		1.00	.09	.60	.02	.53	0	.53	-.11
15			1.00	0	.07	.15	-.23	.11	-.05
16				1.00	.15	.07	.11	-.23	.02
19					1.00	-.20	.69	-.12	-.03
20						1.00	-.12	.69	-.14
21							1.00	-.12	-.10
22								1.00	-.03
25									1.00
26									
27									
28									
29									
30									
47									
48									
51									
52									
55									
56									
58									
59									
62									
63									
64									
67									
68									
Y_1									
Y_2									
Y_3									

TABLE II (continued)

Variables**	26	27	28	29	30	47	48	51	52
1	.03	-.13	.13	-.02	.02	-.04	.04	.07	-.07
2	-.10	-.13	-.05	0	-.19	.21	-.27	-.13	-.05
3	-.01	-.05	-.13	-.22	0	-.27	.21	-.05	-.13
5	-.03	-.04	-.07	.04	-.15	.23	-.34	-.06	.09
6	.04	-.07	-.04	-.13	.04	-.34	.23	.09	-.06
8	.19	.09	-.04	.01	-.03	.33	-.31	.08	.04
9	-.14	-.04	.09	-.03	-.05	-.31	.33	.37	.08
10	-.08	-.05	0	.09	-.10	.05	-.28	-.13	.11
11	.08	0	-.05	-.05	.12	-.28	.05	.11	-.13
12	-.11	-.14	.02	-.06	-.09	.04	.02	-.11	-.18
13	-.08	.02	-.14	-.16	-.05	.02	.04	-.18	-.11
15	.02	-.02	-.06	-.13	-.05	-.13	.25	.03	-.15
16	-.05	-.06	-.24	-.07	-.13	.25	-.13	-.15	.03
19	-.14	-.06	.03	.03	.09	.23	-.34	-.17	.04
20	-.03	.03	-.06	-.04	.03	-.35	.23	.04	-.17
21	-.03	.09	.07	.12	0	.12	-.30	-.24	0
22	-.10	.07	.09	-.03	.10	-.30	.12	0	-.24
25	-.08	-.12	.01	.01	-.03	-.05	.04	.02	-.02
26	1.00	.01	-.12	.02	-.02	.04	-.05	-.02	.02
27		1.00	.15	.04	.19	-.04	0	-.09	.04
28			1.00	.42	0	0	-.04	.04	-.09
29				1.00	.03	.15	-.14	.12	.10
30					1.00	-.09	.08	.11	.12
47						1.00	-.26	-.12	.11
48							1.00	.11	-.12
51								1.00	.01
52									1.00
55									
56									
58									
59									
62									
63									
64									
67									
68									
Y_1									
Y_2									
Y_3									

TABLE II (continued)

Variables**	55	56	58	59	61	62	63	64	67
1	-.29	.29	-.10	.10	-.28	.28	-.18	.18	-.27
2	.35	-.28	.55	-.28	.80	-.32	.56	-.06	.66
3	-.28	.35	-.28	.55	-.32	.80	-.06	.56	-.34
5	.27	-.37	.48	-.39	.67	-.40	.41	-.03	.66
6	-.37	.27	-.39	.48	-.40	.67	-.03	.41	-.31
8	.19	-.27	.72	-.57	.57	-.54	0	.03	.52
9	-.27	.19	-.57	.72	-.54	.57	.03	0	-.42
10	.20	-.37	.19	-.32	.41	-.37	.38	-.14	.49
11	-.37	.20	-.32	.19	-.37	.41	-.14	.38	-.33
12	.18	.05	.22	.07	.37	.04	.34	-.05	.16
13	.05	.18	.07	.22	.04	.37	-.05	.33	-.11
15	-.09	.36	.15	.39	.03	.36	.04	.03	-.17
16	.36	-.09	.39	.15	.36	.03	.03	.04	.17
19	.16	-.19	.20	-.22	.44	-.14	.25	-.12	.39
20	-.19	.16	-.22	.20	-.14	.44	-.12	.25	-.29
21	.19	-.31	.18	-.31	.45	-.24	.29	-.01	.44
22	-.31	.19	-.31	.18	-.24	.45	-.01	.29	-.28
25	.14	-.06	-.20	.25	-.13	-.01	.15	-.21	-.03
26	-.06	.14	.25	-.20	-.01	-.13	-.21	.15	.01
27	-.10	-.21	-.09	-.09	-.13	-.18	-.21	.04	-.05
28	-.21	-.10	-.09	-.09	-.18	-.13	-.04	-.21	-.09
29	.01	-.02	-.07	-.09	-.09	-.16	.02	-.23	.08
30	-.05	0	-.07	-.15	-.12	-.09	-.21	-.02	.01
47	.13	-.08	.28	-.19	.24	-.26	0	-.12	.14
48	-.08	.13	-.19	.28	-.26	.24	-.12	-.01	-.23
51	-.04	.30	.11	-.07	-.03	.02	-.09	.07	-.10
52	.30	-.04	-.07	.11	.02	-.03	.08	-.09	0
55	1.00	.03	.13	.02	.26	-.16	.17	-.16	.22
56		1.00	.02	.13	-.16	.26	-.16	.17	-.24
58			1.00	-.39	.70	-.34	.06	.07	.49
59				1.00	-.34	.70	.07	.05	-.35
62					1.00	-.20	.37	.06	.72
63						1.00	.06	.37	-.23
64							1.00	.06	.28
67								1.00	-.06
68									1.00
Y_1									
Y_2									
Y_3									

TABLE II (continued)

Variables**	68	Y_1	Y_2	Y_3
1	.27	-.36	-.31	-.25
2	-.34	.70	.74	.48
3	.66	-.70	-.40	-.45
5	-.31	.70	.65	.43
6	.66	-.70	-.49	-.52
8	-.42	.62	.49	.33
9	.52	-.62	-.47	-.40
10	-.33	.51	.46	.37
11	.49	-.51	-.40	-.43
12	-.11	.16	.28	.18
13	.16	-.16	.04	-.02
15	.17	-.33	-.22	-.21
16	-.17	.33	.32	.23
19	-.29	.39	.37	.23
20	.39	-.39	-.24	-.13
21	-.28	.45	.51	.40
22	.44	-.45	-.20	-.25
25	.01	.13	.16	-.03
26	-.03	-.13	-.10	-.07
27	-.09	-.07	-.21	-.13
28	-.05	.07	-.08	-.05
29	-.04	.21	.03	.07
30	-.08	-.14	-.29	.14
47	-.23	.51	.37	.19
48	.15	-.51	-.40	-.37
51	0	.01	-.04	-.16
52	-.10	-.01	-.03	.08
55	-.24	.31	.35	.26
56	.22	-.31	-.17	-.22
58	-.35	.46	.39	.20
59	.49	-.46	-.30	-.26
61	-.23	.61	.63	.35
62	.72	-.61	-.35	-.40
63	-.06	.27	.32	.10
64	.28	-.27	-.15	-.29
67	-.25	.54	.56	.25
68	1.00	-.54	-.31	-.36
Y_1		1.00	.80	.57
Y_2			1.00	.55
Y_3				1.00

* r .05(84) = .21

** For identification of variables see Table I

TABLE III

INDEPENDENT VARIABLES CORRELATING SIGNIFICANTLY*
WITH DEPENDENT VARIABLES

Variables	Y_1**	Y_2***	Y_3****
Home Field Factors			
X_1 Home Field	-.36	-.31	-.25
Total Factors			
X_2 Total Yards Gained	.70	.74	.48
X_3 Total Yards Gained by Opponent	-.70	-.40	-.45
Rushing Factors			
X_5 Total Yards Rushing	.70	.65	.43
X_6 Total Yards Rushing by Opponent	-.70	-.49	-.52
X_8 Number of Rushing Attempts	.62	.49	.33
X_9 Number of Rushing Attempts by Opponent	-.62	-.47	-.40
X_{10} Average Yards Gained per Rushing Attempt	.51	.46	.37
X_{11} Average Yards Gained per Rushing Attempt by Opponent	-.51	-.40	-.43
Passing Factors			
X_{12} Total Yards Passing		.28	
X_{15} Number of Passing Attempts	-.33	-.22	-.21
X_{16} Number of Passing Attempts by Opponent	.33	.32	.23
X_{19} Percent of Passes Completed	.39	.37	.23
X_{20} Percent of Passes Completed by Opponent	-.39	-.24	
X_{21} Average Yards Gained per Pass Attempt	.45	.51	.40
X_{22} Average Yards Gained per Pass Attempt by Opponent	-.45		-.25
Kicking and Kick Return Factors			
X_{27} Average Yards per Punt		-.21	
X_{29} Average Yards Gained per Punt Return	.21		
X_{30} Average Yards Gained per Punt Return by Opponent		-.29	
Turnover Factors			
X_{47} Number of Interceptions Made	.51	.37	
X_{48} Number of Interceptions Made by Opponent	-.51	-.40	-.37

TABLE III (continued)

Variables	Y_1	Y_2	Y_3
Penalty Factors			
X_{55} Total Penalty Yardage	.31	.35	.26
X_{56} Total Penalty Yardage Against Opponent	-.31		-.22
Ball Control Factors			
X_{58} Number of Offensive Plays Run	.46	.39	
X_{59} Number of Offensive Plays Run by Opponent	-.46	-.30	-.26
X_{61} Number of First Downs	.61	.63	.35
X_{62} Number of First Downs by Opponent	-.61	-.35	-.40
X_{63} Average Yards Gained on First Down Plays	.27	.32	
X_{64} Average Yards Gained on First Down Plays by Opponent	-.27		-.29
X_{67} Percentage of Third Downs Converted	.54	.56	.25
X_{68} Percentage of Third Downs Converted by Opponent	-.54	-.31	-.36

* r .05(84) = .21
** Y_1 = point spread
*** Y_2 = points scored
**** Y_3 = winning percentage

point spread certainly supports this contention. Total yards gained also correlated significantly in terms of points scored (.74) and winning percentage (.48). The negative correlations of the factor, total yards gained by opponent (-.70 with point spread, -.40 with points scored, and -.45 with winning percentage) also supported Luptak's contention that holding the opponent to few total yards gained is important.

Allsen and Foster reported a very high biserial correlation of .99 between number of rushing plays and winning.[3] Independent variables concerning number of rushing attempts and number of rushing attempts by opponent were also significantly related to point spread (.62 and -.62, respectively). This tends to support Allsens' and Fosters' findings but not nearly as overwhelmingly as their found relationship of .99. Deromedi's theory in coaching his team centered around ball control through rushing. This, he felt, is the area to concentrate on in striving for team success.[4] A significant correlation between total yards rushing and point spread (.70) supports this theory. Total yards rushing also correlated significantly with points scored (.65) and winning percentage (.43).

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[3]P. E. Allsen and Joseph Foster, "Relationship Between Specific Elements and Won-Loss Record," Athletic Journal, 50:36, May, 1970.

[4]Herb Deromedi, "Offensive Line Techniques - A Part of Ball Control," Athletic Journal, 49:14, June, 1969.

Defense against rushing also seems to be an important area of concentration since the negative correlation of the factor, total yards rushing by opponent, was also significant (-.70 with point spread, -.49 with points scored, and -.52 with winning percentage). The importance of good rushing offense and defense is reinforced also by the correlations of .51 and -.51 between average yards gained per rushing attempt and average yards gained per rushing attempt by opponent, respectively, with the dependent variable of point spread.

It was interesting to note that the variables under the passing factors category, while many were significant, did not correlate very highly with any of the dependent variables. (see Table III) The highest correlation was a .45 between average yards gained per pass attempt and point spread. This would seem to indicate that if a team is going to pass often, it must gain a high amount of yardage with each attempt in order to win. These results would seem to discount some of the ideas of Rockne and Driscoll which state that the perfection of the forward pass and the passing game has become increasingly more critical to the success of a football team.[5,6]

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[5]Dave Driscoll, "Passing by the Numbers," Athletic Journal, 47:60-64, May, 1967.

[6]Knute Rockne, Coaching, (New York: Devin-Adair Company, 1939), p. 59-62.

The kicking and kick return factors did not show to be very critical in terms of the correlations for those variables with any of the Y variables. Only three of these factors related significantly to any of the dependent variables with the highest correlation being a -.29 between average yards gained per punt return by opponent and points scored. The only variable which was significant to point spread was average yards gained per punt return, with a low relationship of .21. The kicking and return game was felt to be critical to the winning of games by many coaches.[7,8,9,10] The results as shown in Tables II and III do not support this idea.

The results shown in the turnover category were interesting in that the two fumble recovery factors were not significant, but the number of interceptions and interceptions by opponent were significant with coefficients of .51 for interceptions and -.51 for opponents' interceptions. Apparently if a team is going to lose the ball via a turnover, it will not hurt as much to fumble it away as it will to

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[7]George A. Hansell, "Meeting the Eight Critical Game Situations," Scholastic Coach, 35:50, May, 1966.

[8]Don Read and Len Read, "The Name of the Game," Athletic Journal, 47:38, May, 1967.

[9]Karl P. Sartore, "Returning the Kick-Off," Athletic Journal, 49:76, April, 1969.

[10]Robert W. Kahler, "Punt with a Purpose," Athletic Journal, 49:12, June, 1969.

throw an interception. This finding agrees somewhat with the theory of King who feels that interceptions are the most critical turnover factor and often can be the turning point in a football game.[11]

The total penalty yardage and points scored relationship was significant, but the relationship was only .35. This was an interesting finding, however, in that it indicated that a team will tend to score more points if it has more penalty yardage stepped off against it. This finding certainly contradicts the ideas of many coaches who feel that penalties serve to set a team back in its quest for success.[12,13] No significant relationship was reported, however, relating penalties with point spread and winning percentage.

Ball control, which is considered by many coaches as being necessary to win, was shown to be significant in four of the six ball control variables investigated. A coefficient of .61 was shown relating number of first downs with point spread and a coefficient of .63 relating the same factor with points scored. In addition, a negative coefficient (-.61) was shown relating number of first downs by opponent with point spread. These findings

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[11]DeWayne King, Jericho: A Modern System of Pass Defense, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1963), p. 60-61.

[12]Hansell, p. 50.

[13]Luptak, p. 58.

agree with those of Allsen and Foster who reported a biserial correlation of .79 between first downs and winning.[14] It seems, therefore, to be important to team success that the team be able to both make first downs and prevent the opponent from making first downs.

Another ball control factor, average yards gained on first down plays and its counterpart, average yards gained on first down plays by opponent, were shown to be significant but with low correlations of .27 and -.27 relating each of these variables respectively to point spread. The final two ball control factors analyzed were of special interest in that they are often cited as being keys to the game by professional football telecasters. These variables are percentage of third down situations converted and percentage of the same converted by opponent. They were shown to be significant in relationship to point spread (.54 and -.54 ,respectively).

The first category cited in Chapter III was that of the home field factor. It was stated that the popular belief was that a team will be at an advantage if it plays at home. The low, although significant, correlations with the three team success variables seem to deny this belief. In fact, the correlation coefficients

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[14]Allsen and Foster, p. 36.

for all three dependent variables were negative (-.36 for point spread, -.31 for points scored, -.25 for winning percentage). This meant that over the past two North Central Conference seasons a football team was actually at an advantage playing away from home.

Regression equation analysis. The regression equations computed to predict point spread are presented in Table IV. This table includes the regression equations developed, their standard error of estimate, multiple correlation, and variance accounted for by the addition of each variable. According to the variance accounted for by the addition of each new variable to the equation, the first ten variables made a significant contribution to the equation ($384.46 > 269.30$). Table V includes a listing of these ten variables in order of entry along with the percentage of variance accounted for by the addition of each variable and the cumulative percentage of variance accounted for after the addition of each variable.

Any equation between numbers two and ten could be used to predict point spread depending upon the amount of time and accuracy desired. If time was a factor, equation three should be used since it accounts for 75 percent of the variance and has a multiple correlation of .86. However, if accuracy was foremost, then equation ten is the best to use since it accounted for 89 percent of the variance and had a multiple correlation of .94.

TABLE IV

REGRESSION EQUATIONS DEVELOPED TO PREDICT POINT SPREAD

	Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
1.	$Y_1 = -.17X_6 + 32.75$	16.45	.70	21,659.08
2.	$Y_1 = -.12X_6 + .99X_2 - 9.51$	13.40	.82	7,624.88
3.	$Y_1 = -.11X_6 + .86X_2 - .42X_{48} - .01$	11.76	.86	3,479.00
4.	$Y_1 = -.12X_6 + 83X_2 - .40X_{48} - .68X_{13} + 11.47$	10.75	.89	1,944.99
5.	$Y_1 = -.10X_6 + .82X_2 - .34X_{48} - .68X_{13} + .32X_{47}$ + 2.48	9.65	.91	1,861.33
6.	$Y_1 = -1.00X_6 + .82X_2 - .35X_{48} - .63X_{13} + .33X_{47}$ + $.29X_{25}$ - 7.00	9.29	.92	624.02
7.	$Y_1 = -.99X_6 + .85X_2 - .36X_{48} - .56X_{13} + .35X_{47}$ + $.29X_{25} + .28X_{51}$ - 13.30	8.91	.93	607.87
8.	$Y_1 = -.99X_6 + .82X_2 - .37X_{48} - .59X_{13} + .35X_{47}$ + $.27X_{25} + .27X_{51} - .24X_{26}$ - 4.77	8.66	.93	407.06

TABLE IV (continued)

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
9. $Y_1 = -.10X_6 + .80X_2 - .39X_{48} - .63X_{13} + .36X_{47}$ $+ .26X_{25} + .27X_{51} - .24X_{26} - .22X_{52} + .63$	8.41	.94	384.73
10. $Y_1 = -.91X_6 + .84X_2 - .36X_{48} - .59X_{13} + .37X_{47}$ $+ .26X_{25} + .27X_{51} - .23X_{26} - .24X_{52} - .29X_{15}$ $+ 2.55$	8.16	.94	384.46
11. $Y_1 = -.90X_6 + .62X_2 - .35X_{48} - .60X_{13} + .36X_{47}$ $+ .29X_{25} + .25X_{51} - .25X_{26} - .26X_{52} - .32X_{15}$ $+ .65X_{61} - .15$	7.99	.95	258.13
12. $Y_1 = -.88X_6 + .59X_2 - .34X_{48} - .57X_{13} + .34X_{47}$ $+ .29X_{25} + .22X_{51} - .25X_{26} - .26X_{52} - .32X_{15}$ $+ .75X_{61} + .37X_{29} - 3.26$	7.90	.95	167.76

* Total Variance 43,833.85

MS Variance 66.33

$F_{.05}(1/46) = 4.06$

TABLE V

RANKING OF VARIABLES BY IMPORTANCE IN PREDICTING POINT SPREAD

Variable		Percentage of Variance Accounted for by Addition of Variable	Cumulative Percentage of Variance Accounted For	R
X_6	Total Yards Rushing by Opponent	49	49	.70
X_2	Total Yards Gained	18	67	.82
X_{48}	Number of Interceptions Made by Opponent	8	75	.86
X_{13}	Total Yards Passing by Opponent	4	79	.89
X_{47}	Number of Interceptions Made	4	83	.91
X_{25}	Average Yards Gained per Kick-Off Return	2	85	.92
X_{51}	Number of Fumble Recoveries	1	86	.93
X_{26}	Average Yards Gained per Kick-Off Return by Opponent	1	87	.93
X_{52}	Number of Fumble Recoveries by Opponent	1	88	.94
X_{15}	Number of Passing Attempts	1	89	.94

The first two variables introduced accounted for 67 percent of the variance and the addition of the third brought the variance accounted for up to 75 percent. Beyond this point, no more than 4 percent of the variance was accounted for by the addition of another variable. (see Table V). It was interesting to note that the top three variables involved three different aspects of the game. The most important predictor of point spread, yards rushing by opponent (X_6), accounted for 49 percent of the variance. This reinforces the ideas of many coaches who believe that rushing is the best way to control the ball and win the game. However, the fact that the opponent's rushing variable was shown to be such a high predictor of point spread tells the coach that his defense against rushing is the most important area to work on in regard to winning games. The second most important predictor of point spread was total yards gained (X_2). This variable accounted for an additional 18 percent of the variance and together with total yards rushing by opponents accounted for 67 percent of total variance. This fact should tell the coach that he should concentrate on developing a total offense capable of accumulating great amounts of yardage. Once again, this supports the idea of importance of controlling the ball.[15, 16] The third factor introduced

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[15]Luptak, p. 58.

[16]Allsen and Foster, p. 36.

in the regression analysis to predict point spread was number of interceptions by opponent. It accounted for an additional eight percent of the variance and together with the first two variables accounts for 75 percent of the total variance. The fourth and fifth variables which were added to the equation to predict point spread involved the same area of the game as the third variable added, namely the passing game. If the team loses the ball by throwing interceptions, their chances of winning were shown to lessen significantly.[17]

Since the points scored dependent variable did not indicate winning or losing, it was not considered to be as important a measurement of team success as were the other two dependent variables. The regression equations computed to predict points scored are presented in Table VI. According to the variance accounted for by the addition of each succeeding variable to the equation, the first eight variables were significant predictors of points scored ($302.73 > 262.68$). Table VII includes a listing of these eight variables with the percentage of variance that each accounted for. Tables VI and VII indicate that any equation between numbers one and eight could be used to predict points scored. Once again this is dependent upon the amount of time involved and accuracy desired. Equation One accounts for 55 percent of the variation and has a multiple correlation of .74 with points scored, whereas equation Eight accounts for 73 percent of the variance and has a multiple correlation coefficient of .85 with points scored.

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[17]King, p. 60-61.

TABLE VI

REGRESSION EQUATIONS DEVELOPED TO PREDICT POINTS SCORED

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
1. $Y_2 = .94X_2 - 9.80$	9.55	.74	8995.37
2. $Y_2 = .88X_2 + .20X_{47} - 11.09$	9.10	.77	778.93
3. $Y_2 = .88X_2 + .20X_{47} + .26X_{25} - 18.43$	8.80	.79	509.96
4. $Y_2 = .83X_2 + .17X_{47} + .27X_{25} - .16X_{48} - 13.76$	8.52	.81	465.45
5. $Y_2 = .80X_2 + .16X_{47} + .26X_{25} - .16X_{48} - .34X_{30} - 10.86$	8.34	.82	301.31
6. $Y_2 = .93X_2 + .15X_{47} + .29X_{25} - .15X_{48} - .38X_{30} - .15X_{63} - 9.17$	8.15	.83	312.93
7. $Y_2 = .93X_2 + .14X_{47} + .28X_{25} - .13X_{48} - .41X_{30} - .15X_{63} - .22X_{15} - 4.57$	7.99	.84	264.82
8. $Y_2 = .93X_2 + .13X_{47} + .26X_{25} - .12X_{48} - .36X_{30} - .17X_{63} - .28X_{15} - .37X_{27} + 11.02$	7.79	.85	302.73

TABLE VI (continued)

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
9. $Y_2 = .96X_2 + .15X_{47} + .27X_{25} - .12X_{48} - .37X_{30} - .18X_{63} - .30X_{15} - .38X_{27} + .45X_{22} + 7.98$	7.72	.86	141.89
10. $Y_2 = .85X_2 + .15X_{47} + .27X_{25} - .12X_{48} - .41X_{30} - .17X_{63} - .27X_{15} - .37X_{27} + .51X_{22} + .13X_{67} + 5.14$	7.65	.86	131.40

* Total Variance 16478.52

MS Variance 64.70

$F_{.05}$ (1/46) = 4.06

Minimum Variance needed to contribute significantly to the equation = 4.06 X 64.70 = 262.68

TABLE VII

RANKING OF VARIABLES BY IMPORTANCE IN PREDICTING POINTS SCORED

	Variable	Percentage of Variance Accounted for by Addition of Variable	Cumulative Percentage of Variance Accounted For	R
X_2	Total Yards Gained	55	55	.74
X_{47}	Number of Interceptions Made	4	59	.77
X_{25}	Average Yards Gained per Kick-Off Return	3	62	.79
X_{48}	Number of Interceptions Made by Opponent	3	65	.81
X_{30}	Average Yards Gained per Punt Return by Opponent	2	67	.82
X_{63}	Average Yards Gained on First Down Plays	2	69	.83
X_{15}	Number of Passing Attempts	2	71	.84
X_{27}	Average Yards per Punt	2	73	.85

The first variables introduced accounted for 55 percent of the variance and actually beyond that variable, the equations did not offer a great jump in variance accounted for (see Tables VI and VII). The most important variable to predict total points scored was the total yards gained factor. The second variable introduced, number of interceptions made, is interesting in that it would seem to be very important to a team's scoring ability if it can intercept opponents' passes. This indicates that pass defense is an area on which to concentrate. Closely associated with this variable is the fourth important variable, interceptions by opponent. This additionally tells the coach that to generate point scoring ability, the team must either be accurate in its passing game so that the ball is not intercepted or the team must pass sparingly so that the chance of interceptions by the opponent is lessened. The third variable illustrates the importance of having good field position after a kick-off return. Good kick-off return teams, therefore, have a greater capability to score points.

The third dependent variable investigated was winning percentage. This was a definite measurement of team success, although probably not as meaningful as point spread in that it was a constant value for each team and did not explain as much about individual games as did point spread. Regression equations developed to predict winning percentage appear in Table VIII. The first three variables introduced made a significant contribution to the equation ($2869.24 > 2382.61$). The same first three variables which predicted point spread were introduced in the same order to predict winning percentage: total yards rushing

TABLE VIII

REGRESSION EQUATIONS DEVELOPED TO PREDICT WINNING PERCENTAGE

Regression Equation	Standard Error of Estimate	Multiple Correlation	Variance Accounted*
1. $Y_3 = -.16X_6 + 79.37$	24.23	.52	17505.34
2. $Y_3 = -.11X_6 + .78X_2 + 45.86$	23.14	.58	4795.49
3. $Y_3 = -.10X_6 + .66X_2 - .38X_{48} + 54.49$	22.50	.62	2869.24
4. $Y_3 = -.78X_6 + .73X_2 - .41X_{48} - .30X_{64} + 60.13$	22.21	.64	1526.85
5. $Y_3 = -.77X_6 + .99X_2 - .42X_{48} - .31X_{64} - .32X_{67} + 63.93$	22.09	.65	896.39

* Total Variance 65657.31

MS Variance 586.85

$F_{.05}$ (1/46) = 4.06

Minimum variance needed to contribute significantly to the equation = 4.06 X 586.85 = 2382.61

by opponent (X_6), total yards gained (X_2), and number of interceptions by opponent (X_{48}). The winning percentage, however, cannot be very accurately predicted since even with a five variable equation, one can only account for 38 percent of the total variance.

The null hypotheses stated that (1) there is no significant relationship between any of the 68 independent variables and team success in North Central Conference football, and (2) a regression equation to significantly predict team success from the independent variables cannot be developed. Hypothesis number one was rejected because 31 independent variables were shown to be correlated significantly with at least one of the three measurements of team success (see Table III). The second hypothesis was also rejected because the computed variance for the tenth equation for point spread ($383.46 \geq 269.30$), the eighth equation for points scored ($302.73 \geq 262.68$), and the third equation for winning percentage ($2869.24 \geq 2382.61$) were all above the values necessary to provide significant predictions at the .05 level of confidence.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this investigation was to study the relationship between team success in North Central Conference football games to 68 selected objective factors occurring in those games.

Home game statistics and play-by-play sheets obtained from Sports Information Directors at six of the eight North Central Conference institutions and covering 42 football games played in the conference over the 1972 and 1973 seasons provided the data on the 68 selected independent variables and three dependent variables measuring team success. The three dependent variables of team success were total points scored, point spread and winning percentage.

After initially analyzing all 68 independent variables, 31 of the variables were dropped because of their possible interference with the practicality of the study. The final analysis included 37 independent variables. A matrix of intercorrelations between 37 of the independent variables and their correlations with the three dependent variables was developed. From this matrix, regression equations were developed to predict the three dependent variables of team success in North Central Conference football.

In regard to correlations computed between the independent and dependent variables, the results revealed that 28 of the 37 independent variables employed in the final analysis related significantly to point spread, 23 of the independent variables related significantly to

points scored, and 20 of the independent variables related significantly to winning percentage (see Table III).

Concerning the regression equation analysis, it was found that point spread could be significantly predicted from a combination of ten independent variables. In order of importance they are: opponent's total rushing yardage, total yards gained, opponent's interceptions made, opponent's passing yards, interceptions made, yards gained per kick-off return, fumble recoveries, opponent's kick-off return yardage, opponent's fumble recoveries, and number of passing attempts. The multiple correlation for the tenth variable equation with point spread was .95. With just the first three variables, the multiple correlation was .86. Points scored can be significantly predicted from a combination of eight independent variables. In order of importance they are: total yards gained, interceptions made, kick-off return yardage, opponent's interceptions made, opponent's punt return yardage, yards gained on first down, number of passing attempts, and punting average. The multiple correlation for the eighth variable equation with total points scored was .86. Winning percentage can be significantly predicted from a combination of the three independent variables of opponent's total rushing yardage, total yards gained, and opponent's interceptions made. The multiple correlation was .62.

Conclusions

Based on the results of the study and within its limitations, the following conclusions were made:

1. Numerous statistical factors normally measured in a football game do relate significantly to team success.

2. Team success in North Central Conference football can be significantly predicted from combinations of objective statistical factors occurringin conference football games.

Recommendations for Further Research

Based on the findings of this study, the investigator proposes the following recommendations for further study:

1. That similar studies be conducted at other levels of football competition, such as high school, major college, and professional.

2. That a study be conducted employing only offensive statistics to predict team success.

3. That further study be conducted using the same independent variables but analyzing them by using t-ratios to compare the differences in each variable between winning and losing teams.

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APPENDICES

APPENDIX A

LETTER TO SPORTS INFORMATION DIRECTORS

Department of HPER
South Dakota State University
Brookings, South Dakota 57006

Dear Mr. Lenz:

Enclosed is a proposal for a research study which has been accepted by the Health, Physical Education and Recreation Department at South Dakota State University for my Master of Science thesis.

I am trying to discover which factors of a football game have related most to team success in North Central Conference Football. The findings of this study may be of value to a coach in deciding what areas of the game he needs to concentrate on in practice sessions. There also may be some factors which are very important that have been downplayed or overlooked by the coach.

I would like to ask for your support in obtaining the statistics that will be needed to complete this study. Specifically, I will need the standard statistic and play-by-play sheet kept for each NCC home game played by your team during both the 1972 and 1973 seasons.

I would be happy to mail you a copy of the results of the study when it has been completed.

Thank you for your support.

Sincerely yours,

Larry Langemo

Paul Degnitson
Research Coordinator HPER

Gloria Robinson, Coordinator
Graduate HPER Program

APPENDIX B

SAMPLE STATISTIC SHEET

Order Form 681 from John Fountain, 2575 Maple Street, Ypsilanti, Michigan 48197

University of Northern Iowa (4-5-1) at South Dakota State University (5-4) Nov. 3 1973

SDSU JACKS			UNI PANTHERS
FIRST DOWNS	24	13	FIRST DOWNS
by rushing 16			9 by rushing
by passing 5			4 by passing
by penalty 3			0 by penalty
NET YARDS RUSHING	378	112	NET YARDS RUSHING
attempts 74 50			48 attempts
gained 404			132 gained
lost 26			69 lost
NET YARDS PASSING	86	86	NET YARDS PASSING
completed 6			6 completed
attempted 19			20 attempted
had intercepted 2			1 had intercepted
TOTAL OFFENCE	464	199	TOTAL OFFENSE
plays rush, pass 393			63 plays rush, pass
RETURN YARDAGE	40	14 one	RETURN YARDAGE
punts 40			5 29 punts
~~kickoffs~~			~~kickoffs~~
Interceptions 0			9 interceptions
PUNTING (No./Ave.)	4/39	7/32.7	PUNTING (No./Ave.)
PENALTIES (No./Yds.)	4/24	6/52	PENALTIES (No./Yds.)
FUMBLES (No./Lost)	2/1	1/1	FUMBLES (No./Lost)

Teams	1	2	3	4	Final
UNI	0	0	0	0	0
SDSU	0	10	0	6	16

GAME CONDITIONS

Temperature 33° Skies Cloudy

Wind WNW 3 Turf Good

AT TODAY'S GAME 1,022

OFFICIALS

Ref: Anderson Judge: Greeno

Ump: Christensen Line: Ford

GAME NOTES

— This is SDSU's 7th and final home game of 1973, most ever in any one year.

— Clarkson's interception sets new career record of 13. Old mark was 12 by Wayne Rasmussen 1961-63. *

Tuna's 240 yds. new SDSU single game record. Old mark 224 by Conerman in 1967 against Drake. * didn't play 4th Q - injured

Team	Qtr-Time	Scoring Play	Length-Drive	Plays	Score
SDSU	2nd 8:03	Tuna 57yd run - Doty Kick good	71	3	7-0
SDSU	2nd 4:04	Doty 25 FG	34	12	10-0
SDSU	3rd 6:05	Tuna 1yd run - Doty kick No good	42	11	16-0

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APPENDIX B (continued)

SAMPLE PLAY-BY-PLAY SHEET

3rquarter SDSU vs UNI play-by-play Nov. 3, 1973

Smith kicks off to Tuna on the 6, returns to 20
SD 20, 1-10--Tuna carries for 9
SD 29, 2-1--Tuna carries for 2, fuble to 28, recovered brown
SD[28], 1-10--Salmon carries for 2
SD 26, 2-8--Salmon pass intercepted by Clarksean on 21 *
SD[21], 1-10--Tuna carries for 47
UNI 32, 1-10--Kennedy carries for 3
UNI 29, 2-7--Tovar carries for 2
UNI 27, 3-5--Kennedyd carries for 4
UNI 23, 4-1--Decker loses 5
& UNI 28, 1-10--Salmon pass to Hillman for 37
SD 35, 1-10--Batten carries for [illegible] loss of 1
SD 36, 2-11--Salmon pass to Rainey for 11
SD 25, 1-10--Hodam carries 1
SD 24, 2-9--Salmon pass incomplete
SD 24, 3-9--Salmon loses 13
SD 37, 4-22--Smith FG attempt from 45, Wertish returns 15
SD 19, 1-10--Tuna carries for 24
SD 43, 1-10--Kennedy carries for 3
SD 46, 2-7--Kennedy carries for 2
SD 48, 3-5--Decker carries for 7
UNI 45, 1-10--Tuna carries for 1
UNI 44, 2-9--Tuna carries for 4
UNI 40, 2-5--Tovar pass to Dickey for 11
UNI 29, 1-10--Kennedy carries for 2
UNI 27, 2-8--Tovar pass incomplete
UNI 27, 3-8--Tovar pass incomplete
UNI 27, 4-8--Doty [illegible] 45 FG attempt no good OFFSIDES UNI
UNI 22, 4-3--Doty loses 1
UNI 23, 1-10--Hodam carries for 10
UNI 33, 1-10--OFFSIDES SDSU
UNI 38, 1-5--Salmon carries for 22
SD 40, 1-10--Hodam carries for 1
SD 39, 2-9--Salmon pass incomplete
SD 39, 3-9--Salmon pass incomplete
SD 39, 4-9--[illegible] Fransen punt from 39 to Wertish on 6, return to 22
CLIPPING SDSU ON 18
SD 9, 1-10--Tuna carries for 2
SD 11, 2-8--Tuna carries for 2
SD 13, 3-6--Tuna carries for 12
SD 25, 1-10--Kennedy loses 2
SD 23, 2-12--Decker carries for 3
SD 26, 3-9--Bonnell carries for 8
SD 33, 4-1--Doty punt to UNI 41, no return
UNI 41, 1-10--Hodam carries for no gain
UNI 41, 2-10--Salmon pass to Schooley for 22
SD[37], 1-10--Batten carries for 6
SD 31, 2-4--Salmon pass incomplete

APPENDIX C

TABLE IX

RAW DATA FOR HOME GAMES
OF SOUTH DAKOTA STATE UNIVERSITY

*Variables	Opponent						
	USD	Augustana	NDSU	Morningside	UND	UNI	Mankato
X_1	1	1	1	1	1	1	1
X_2	209	430	234	381	272	464	241
X_3	412	234	265	162	438	199	294
X_4	34	65	47	70	38	70	45
X_5	147	215	97	280	119	378	176
X_6	394	99	193	121	305	113	168
X_7	27	69	34	70	28	77	51
X_8	51	62	50	53	43	74	40
X_9	76	45	52	64	71	48	74
X_{10}	2.9	3.5	1.9	5.3	2.8	5.1	4.4
X_{11}	5.2	2.2	3.7	1.9	4.3	2.4	2.3
X_{12}	62	215	137	101	153	86	65
X_{13}	18	135	72	41	133	86	126
X_{14}	78	61	66	71	54	50	34
X_{15}	15	21	30	18	25	19	24
X_{16}	6	26	13	29	20	20	23
X_{17}	6	11	12	8	9	6	7
X_{18}	1	8	5	5	10	6	12
X_{19}	40	52	40	44	36	32	29
X_{20}	17	31	39	17	50	30	52
X_{21}	4.1	10.2	4.6	5.6	6.1	4.5	2.7
X_{22}	3	5.2	5.5	1.4	6.7	4.3	5.5
X_{23}	10.3	19.6	11.4	12.6	17	14.3	9.3
X_{24}	18	16.9	14.4	8.2	13.3	14.3	10.5
X_{25}	25.8	26.3	28.3	93	23.1	20	24
X_{26}	26	30.6	31.3	24.8	33.5	31.8	0
X_{27}	39.3	42.8	36.1	40.6	36.9	39	33.4
X_{28}	25.8	38.5	33.7	35.3	21.7	39.9	40.3
X_{29}	0	2	2.7	5.4	0	3.6	10.1
X_{30}	6.7	13.3	15.6	7.7	-1	1.3	9.1
X_{31}	1	3	2	5	3	2	0
X_{32}	5	2	3	0	7	0	3
X_{33}	1	1	0	0	0	1	0

TABLE IX (continued)

*Variables	USD	Augustana	NDSU	Morningside	UND	UNI	Mankato
X_{34}	1	0	1	0	1	0	0
X_{35}	100	50	0	0	0	33	0
X_{36}	25	0	50	0	100	0	0
X_{37}	1	2	2	5	3	1	0
X_{38}	3	2	3	0	2	0	3
X_{39}	100	100	100	100	100	50	0
X_{40}	75	100	100	0	40	0	100
X_{41}	0	0	0	0	0	0	0
X_{42}	0	0	0	0	2	0	0
X_{43}	0	0	0	0	0	0	0
X_{44}	0	0	0	0	100	0	0
X_{45}	0	1	0	0	0	0	0
X_{46}	0	0	0	0	0	0	0
X_{47}	0	3	2	1	1	1	0
X_{48}	3	2	6	2	3	2	5
X_{49}	0	3	12.5	15	9	0	0
X_{50}	14.3	2.5	11.8	0	4.8	4.5	6
X_{51}	3	3	2	2	1	1	1
X_{52}	4	0	1	2	1	1	2
X_{53}	12	8	6	9	2	4	7
X_{54}	6	4	9	1	4	6	3
X_{55}	112	80	50	92	7	24	70
X_{56}	57	26	84	15	51	50	25
X_{57}	66	75	37	86	12	32	74
X_{58}	66	83	80	71	68	93	64
X_{59}	82	71	65	93	91	68	97
X_{60}	45	54	55	43	43	58	40
X_{61}	14	11	15	16	13	24	15
X_{62}	18	8	11	15	23	13	21
X_{63}	4.7	3.6	1.8	6	3.4	6.4	4.1
X_{64}	5.1	2.2	3.9	1.3	3.2	5.2	2.1
X_{65}	4	8	8	6	5	9	5
X_{66}	7	2	3	8	7	6	14
X_{67}	25	40	40	43	31	43	42
X_{68}	37	15	21	31	39	35	44
Y_1	-26	+11	-10	+35	-30	+16	-21
Y_2	10	25	14	35	21	16	0
Y_3	29	29	29	29	29	29	29

* For identification of variables see Chapter III

APPENDIX D

TABLE X

RAW DATA FOR HOME GAMES
OF UNIVERSITY OF SOUTH DAKOTA

*Variables	Opponent						
	SDSU	Augustana	NDSU	Morningside	UND	UNI	Mankato
X_1	1	1	1	1	1	1	1
X_2	501	410	415	520	349	363	458
X_3	241	236	329	230	474	238	263
X_4	68	64	56	69	42	60	64
X_5	218	357	323	442	131	315	396
X_6	144	168	86	130	300	182	84
X_7	60	68	79	78	30	63	83
X_8	58	80	65	65	41	77	72
X_9	58	38	34	46	70	44	32
X_{10}	3.8	4.5	5	6.8	3.2	4.1	5.5
X_{11}	2.5	4.4	2.5	2.8	4.3	4.1	2.6
X_{12}	283	53	92	78	218	48	62
X_{13}	97	68	243	100	174	56	179
X_{14}	75	44	28	44	56	46	26
X_{15}	17	3	12	24	29	5	4
X_{16}	12	17	40	32	17	15	27
X_{17}	10	2	6	5	11	1	3
X_{18}	6	4	17	13	10	5	14
X_{19}	59	67	50	21	38	20	75
X_{20}	50	24	43	41	59	33	52
X_{21}	16.7	17.7	7.7	3.3	7.5	9.6	15.5
X_{22}	8.1	4	6.1	3.1	10.2	3.7	6.6
X_{23}	23.6	26.5	15.3	15.6	19.8	48	20.7
X_{24}	16.2	17	14.3	7.7	17.4	11.2	12.8
X_{25}	21.2	27.8	26.8	29	26.3	13.5	26
X_{26}	26.9	35.2	29	26	22.8	36.8	32
X_{27}	35.3	41.6	37.2	28	33.8	47.2	38
X_{28}	38.3	34.8	34	17	34.0	39.9	35.1
X_{29}	5.1	14.2	-1.5	4.7	-2	.9	3
X_{30}	4	14.7	.6	0	2.2	1.1	6.7
X_{31}	6	4	5	9	3	3	5
X_{32}	4	3	3	1	8	1	0
X_{33}	0	0	0	0	0	0	1
X_{34}	0	0	0	0	0	0	1

TABLE X (continued)

*Variables	SDSU	Augustana	NDSU	Morningside	UND	UNI	Mankato
X_{35}	0	0	0	0	0	0	100
X_{36}	0	0	0	0	0	0	100
X_{37}	6	4	5	6	3	3	5
X_{38}	3	3	3	1	4	1	0
X_{39}	100	100	100	75	100	100	100
X_{40}	75	100	100	100	80	100	0
X_{41}	0	0	0	0	0	0	0
X_{42}	0	0	0	0	1	0	0
X_{43}	0	0	0	0	0	0	0
X_{44}	0	0	0	0	33	0	0
X_{45}	0	0	0	0	0	0	0
X_{46}	0	0	0	0	0	0	0
X_{47}	2	0	2	3	1	2	2
X_{48}	1	0	0	0	4	0	0
X_{49}	2	0	.5	0	0	6	58
X_{50}	8	0	0	0	8.3	0	0
X_{51}	0	1	1	3	0	1	1
X_{52}	3	3	0	3	2	1	2
X_{53}	11	4	6	12	6	5	6
X_{54}	6	2	5	6	7	3	3
X_{55}	96	37	70	131	49	48	53
X_{56}	44	20	35	88	66	25	15
X_{57}	68	65	67	60	43	66	78
X_{58}	75	83	77	89	70	82	76
X_{59}	70	55	74	78	87	59	59
X_{60}	52	60	51	53	45	58	56
X_{61}	20	21	18	26	14	20	25
X_{62}	14	13	19	18	24	11	12
X_{63}	5.6	3.7	3.9	5.6	5.7	2.9	5.1
X_{64}	3.4	5.3	4.2	4.3	3.4	3.8	3.8
X_{65}	7	13	8	6	5	12	7
X_{66}	3	3	4	6	10	6	2
X_{67}	50	65	40	60	31	55	47
X_{68}	27	27	27	32	50	38	15
Y_1	+15	+7	+14	+53	-33	+14	+35
Y_2	42	28	35	60	21	21	38
Y_3	83	83	83	83	83	83	83

*For identification of variables see Chapter III

TABLE XI (continued)

*Variables	SDSU	USD	NDSU	Morningside	UND	UNI	Mankato
X_{34}	0	0	1	0	0	0	1
X_{35}	0	0	0	0	100	0	100
X_{36}	0	0	100	0	0	0	100
X_{37}	3	2	1	3	2	2	2
X_{38}	3	3	0	1	2	0	1
X_{39}	100	100	100	60	100	66.7	66.7
X_{40}	100	100	0	100	100	0	100
X_{41}	0	0	0	0	0	0	0
X_{42}	0	0	0	0	1	1	0
X_{43}	0	0	0	0	0	0	0
X_{44}	0	0	0	0	100	100	0
X_{45}	0	0	0	0	1	0	0
X_{46}	0	0	0	0	0	0	0
X_{47}	0	1	1	6	1	0	1
X_{48}	0	1	2	0	1	4	1
X_{49}	0	6	13	17.8	0	0	6
X_{50}	0	0	27	0	0	1.5	0
X_{51}	2	1	2	0	1	1	0
X_{52}	2	1	2	2	1	1	0
X_{53}	8	6	5	2	0	2	7
X_{54}	7	6	5	3	7	2	6
X_{55}	76	55	55	20	0	20	81
X_{56}	62	69	43	31	75	20	80
X_{57}	55	44	56	39	0	50	50
X_{58}	76	63	61	60	87	74	79
X_{59}	70	86	73	71	77	64	77
X_{60}	52	42	46	46	53	54	51
X_{61}	20	16	15	14	21	19	22
X_{62}	16	21	17	13	17	15	12
X_{63}	4.5	5.5	3.3	3.8	3.9	11.0	6.3
X_{64}	4.4	3.3	3.2	3	7.6	6.1	2.9
X_{65}	5	7	4	4	5	7	5
X_{66}	9	12	8	8	4	2	6
X_{67}	33	47	33	36	33	44	31
X_{68}	50	60	44	44	31	15	32
Y_1	0	-7	-2	+26	-4	+6	+13
Y_2	21	14	7	33	16	20	23
Y_3	38	38	38	38	38	38	38

* For identification of variables see Chapter III

APPENDIX F

TABLE XII

RAW DATA FOR HOME GAMES
OF NORTH DAKOTA STATE UNIVERSITY

*Variables	Opponent						
	SDSU	USD	Augustana	UND	Morningside	UNI	Mankato
X_1	1	1	1	1	1	1	1
X_2	404	248	397	321	534	331	339
X_3	458	261	310	208	172	89	335
X_4	48	49	56	61	76	79	50
X_5	248	114	353	268	380	233	233
X_6	138	170	99	80	69	75	134
X_7	64	40	78	77	85	76	64
X_8	55	43	57	55	66	51	53
X_9	42	52	42	48	28	52	36
X_{10}	4.5	2.7	6.2	4.9	5.8	4.6	4.4
X_{11}	3.3	3.3	2.4	1.7	2.5	1.4	3.7
X_{12}	156	134	44	53	144	99	106
X_{13}	320	91	211	128	103	14	209
X_{14}	33	60	17	29	58	88	51
X_{15}	25	21	13	17	17	14	15
X_{16}	37	21	23	31	42	12	35
X_{17}	9	10	4	5	9	6	6
X_{18}	16	8	10	13	14	1	20
X_{19}	36	48	31	29	53	43	40
X_{20}	43	38	44	42	33	8	57
X_{21}	6.2	6.4	3.4	3.1	8.5	7.1	7.1
X_{22}	8.7	4.3	9.2	4.1	2.5	1.2	6
X_{23}	17.3	13.4	11	10.6	16	16.5	17.7
X_{24}	20	11.4	21.1	9.9	7.4	14	10.5
X_{25}	36.3	18.5	26	32.7	21	24	20
X_{26}	24.8	42	19	30.3	18.3	24.8	26.3
X_{27}	35.2	34.8	25.7	36.2	41	34.2	44.6
X_{28}	39.4	37.2	32	30.6	34.1	43.3	38
X_{29}	12.8	8.2	3.5	.4	1.7	14.8	7.5
X_{30}	1.3	-2.9	0	3.6	6.8	4	4
X_{31}	5	1	5	3	7	3	3
X_{32}	2	1	3	2	1	0	2
X_{33}	0	0	1	0	0	0	0

TABLE XII (continued)

*Variables	SDSU	USD	Augustana	UND	Morningside	UNI	Mankato
X_{34}	1	1	1	0	0	0	1
X_{35}	0	0	33	0	0	0	0
X_{36}	50	50	50	0	0	0	100
X_{37}	4	1	3	3	6	3	3
X_{38}	1	0	3	2	0	0	2
X_{39}	80	100	75	100	86	100	100
X_{40}	100	0	100	100	0	0	100
X_{41}	0	0	1	0	0	0	0
X_{42}	0	0	0	0	0	0	0
X_{43}	0	0	100	0	0	0	0
X_{44}	0	0	0	0	0	0	0
X_{45}	0	0	1	0	0	0	0
X_{46}	0	0	0	0	0	0	0
X_{47}	4	0	2	2	0	3	0
X_{48}	0	3	1	4	0	0	1
X_{49}	14.3	0	21	17	0	9.3	0
X_{50}	0	10	10	10	0	0	12
X_{51}	1	1	1	1	0	1	3
X_{52}	2	1	1	2	1	2	2
X_{53}	9	8	5	5	6	11	4
X_{54}	11	5	1	3	0	6	5
X_{55}	100	77	65	45	70	120	58
X_{56}	104	48	15	20	0	60	57
X_{57}	49	62	81	69	100	67	50
X_{58}	80	64	70	72	83	65	68
X_{59}	79	73	65	79	70	64	71
X_{60}	50	47	52	48	54	50	49
X_{61}	17	12	19	15	27	11	19
X_{62}	17	12	15	15	11	9	18
X_{63}	4.1	3	5.2	3.4	4.3	5.6	4.3
X_{64}	5.3	2.6	4.2	2	2.6	.7	6.7
X_{65}	4	4	5	8	10	5	6
X_{66}	6	4	8	6	6	1	8
X_{67}	31	25	39	47	63	31	40
X_{68}	38	20	40	29	35	66	47
Y_1	+18	-2	+16	+7	+42	+21	+4
Y_2	34	7	40	21	48	21	21
Y_3	83	83	83	83	83	83	83

*For identification of variables see Chapter III

APPENDIX G

TABLE XIII

RAW DATA FOR HOME GAMES OF UNIVERSITY OF NORTH DAKOTA

*Variables	Opponent						
	SDSU	Augustana	USD	NDSU	Morningside	UNI	Mankato
X_1	1	1	1	1	1	1	1
X_2	423	483	357	298	552	526	382
X_3	235	357	101	262	195	145	162
X_4	64	58	78	53	74	78	70
X_5	188	227	187	108	245	198	226
X_6	124	168	51	114	62	81	92
X_7	60	58	79	49	80	71	71
X_8	61	55	68	43	58	53	60
X_9	58	45	37	48	38	46	42
X_{10}	3.1	4.1	2.8	2.5	4.2	3.7	3.8
X_{11}	2.1	3.7	1.4	2.4	1.6	1.8	2.2
X_{12}	235	256	170	190	307	328	156
X_{13}	111	191	50	148	133	64	70
X_{14}	68	57	77	56	70	84	69
X_{15}	33	25	21	33	25	37	18
X_{16}	24	18	20	26	32	17	23
X_{17}	11	12	13	17	15	21	8
X_{18}	13	10	4	9	10	6	8
X_{19}	33	48	62	52	60	57	44
X_{20}	54	56	20	35	24	35	35
X_{21}	7.1	10.2	8.1	5.8	12.3	8.9	8.7
X_{22}	7.6	10.6	2.5	5.7	4.2	3.8	3.0
X_{23}	21.4	21.3	13.1	11.2	20.5	15.6	19.5
X_{24}	8.5	19.1	12.5	16.4	13.3	10.7	8.8
X_{25}	25.8	20.7	35	31	27	26	41
X_{26}	25.8	29	26.5	33.3	25.8	25.9	28.8
X_{27}	33.9	40	34.9	26	38.8	32.3	30.7
X_{28}	35.7	34.2	36.4	37.7	29.5	39	31.5
X_{29}	.4	3.6	3.5	6.8	6.6	9	1.4
X_{30}	3.4	3.4	1.7	8	1.3	0	-.5
X_{31}	4	5	5	3	6	5	7
X_{32}	2	5	0	2	1	1	2
X_{33}	0	1	0	1	1	1	0

TABLE XIII (continued)

*Variables	SDSU	Augustana	USD	NDSU	Morningside	UNI	Mankato
X_{34}	2	0	1	0	0	1	0
X_{35}	0	50	0	33	50	100	0
X_{36}	100	0	100	0	0	50	0
X_{37}	4	5	3	2	4	1	6
X_{38}	2	4	0	2	1	0	2
X_{39}	100	100	75	100	67	33	86
X_{40}	100	80	0	100	100	0	100
X_{41}	0	0	0	0	0	2	0
X_{42}	0	0	0	1	0	0	0
X_{43}	0	0	0	0	0	100	0
X_{44}	0	0	0	100	0	0	0
X_{45}	0	0	0	0	0	0	0
X_{46}	0	0	0	0	0	0	0
X_{47}	2	1	0	2	5	3	2
X_{48}	4	1	0	2	1	2	1
X_{49}	3	0	0	14.5	9.2	10.3	18.5
X_{50}	8.5	0	0	5	5	32.5	22
X_{51}	2	2	4	1	0	3	2
X_{52}	1	0	2	1	3	1	0
X_{53}	8	7	7	5	11	9	8
X_{54}	2	5	5	6	4	8	8
X_{55}	88	64	91	62	147	85	79
X_{56}	10	104	52	53	35	84	121
X_{57}	90	38	64	54	81	50	40
X_{58}	72	80	89	76	83	90	78
X_{59}	82	63	57	74	70	63	65
X_{60}	47	56	61	51	54	59	55
X_{61}	19	24	20	17	28	26	20
X_{62}	15	19	7	22	15	10	13
X_{63}	2.5	5.3	2.1	2.4	6.1	5.7	4.8
X_{64}	3.9	3.4	3.6	2.7	3	2.3	5.4
X_{65}	8	7	12	5	8	9	11
X_{66}	6	10	0	6	4	4	5
X_{67}	36	44	53	28	50	47	58
X_{68}	30	59	0	33	25	27	29
Y_1	+8	+4	+30	-5	+36	+29	+34
Y_2	28	38	33	17	43	38	48
Y_3	75	75	75	75	75	75	75

* For identification of variables see Chapter III

APPENDIX H

TABLE XIV

RAW DATA FOR HOME GAMES
OF UNIVERSITY OF NORTHERN IOWA

*Variables	Opponent						
	SDSU	USD	Augustana	NDSU	UND	Mankato	Morningside
X	1	1	1	1	1	1	1
X_1	223	67	316	230	372	361	359
X_2	289	268	413	414	377	195	208
X_3	44	20	43	36	50	65	63
X_4	102	0	153	10	283	238	264
X_5	156	181	334	160	131	117	128
X_6	40	0	31	41	68	67	67
X_7	59	36	45	48	76	63	49
X_8	48	59	66	55	34	39	47
X_9	1.7	0	3.4	2.3	3.7	3.8	5.4
X_{10}	3.3	12.1	5.1	2.9	3.9	3	2.7
X_{11}	121	67	163	120	89	123	95
X_{12}	133	87	100	254	246	78	80
X_{13}	48	44	62	32	27	61	54
X_{14}	18	13	16	23	13	19	12
X_{15}	29	13	19	24	40	26	17
X_{16}	7	4	6	11	5	11	7
X_{17}	10	5	11	16	23	11	4
X_{18}	39	31	38	48	38	58	58
X_{19}	35	38	58	67	58	42	24
X_{20}	6.7	5.2	10.2	5.2	6.9	6.5	7.9
X_{21}	4.6	6.7	5.3	10.6	6.2	3	4.7
X_{22}	17.3	16.8	27.2	10.9	17.8	11.2	13.6
X_{23}	13.3	17.4	9.1	15.9	10.7	7.1	20
X_{24}	19	33.8	22.2	22.4	27.3	23	29.7
X_{25}	20.3	21.5	28.3	27	28.3	28.7	37.6
X_{26}	34.7	39.8	44.3	46	34	40	36.2
X_{27}	46.6	37.7	44	31	30	37.4	32
X_{28}	9.3	7.7	10.5	1.3	-1	7.4	3.3
X_{29}	1.8	6.3	8	6.1	4	4.4	11.2
X_{30}	5	1	1	0	2	3	4
X_{31}	0	3	5	6	2	0	2
X_{32}	0	0	1	0	1	0	0
X_{33}							

TABLE XIV (continued)

*Variables	SDSU	USD	Augustana	NDSU	UND	Mankato	Morningside
X_{34}	0	0	0	0	0	0	0
X_{35}	0	0	50	0	100	0	0
X_{36}	0	0	0	0	0	0	0
X_{37}	2	1	0	0	2	3	3
X_{38}	0	1	4	6	2	0	1
X_{39}	50	100	0	0	100	100	75
X_{40}	0	50	100	100	100	0	50
X_{41}	0	0	0	0	0	0	0
X_{42}	0	0	1	0	0	0	0
X_{43}	0	0	0	0	0	0	0
X_{44}	0	0	100	0	0	0	0
X_{45}	0	0	0	0	0	0	0
X_{46}	0	0	0	0	0	0	0
X_{47}	4	0	0	0	3	4	6
X_{48}	1	0	3	3	1	1	1
X_{49}	7.3	0	0	0	9.3	3.5	13
X_{50}	0	0	21.3	7.3	0	4	0
X_{51}	4	2	2	1	1	2	0
X_{52}	2	1	2	1	3	2	3
X_{53}	4	3	4	6	6	8	7
X_{54}	5	7	3	5	2	7	4
X_{55}	37	25	42	58	91	106	65
X_{56}	55	52	25	60	10	51	40
X_{57}	40	32	63	49	90	68	62
X_{58}	77	49	61	71	89	82	61
X_{59}	77	74	85	79	74	65	64
X_{60}	50	40	42	47	55	55	49
X_{61}	16	4	13	16	24	22	20
X_{62}	18	13	25	21	21	14	12
X_{63}	3.7	2.2	2.4	2.1	4.2	4.2	3.9
X_{64}	3.2	2.4	6.2	3.5	6	3.6	3.3
X_{65}	5	0	3	6	9	7	9
X_{66}	3	6	12	6	8	3	3
X_{67}	26	0	25	38	43	39	64
X_{68}	20	35	67	43	47	23	20
Y_1	+32	-12	-27	-42	+3	+21	+14
Y_2	32	7	9	0	17	21	27
Y_3	33	33	33	33	33	33	33

* For identification of variables see Chapter III

APPENDIX E

TABLE XI

RAW DATA FOR HOME GAMES OF AUGUSTANA COLLEGE

*Variables	Opponent						
	SDSU	USD	NDSU	Morningside	UND	UNI	Mankato
X_1	1	1	1	1	1	1	1
X_2	372	333	327	301	366	512	474
X_3	309	413	280	175	441	290	249
X_4	55	45	54	63	46	63	66
X_5	195	182	200	199	178	304	235
X_6	164	344	123	175	199	143	106
X_7	54	35	62	53	47	68	69
X_8	49	41	43	48	52	54	56
X_9	47	77	51	60	52	43	46
X_{10}	4.0	4.4	4.7	4.2	3.4	5.6	4.2
X_{11}	3.6	4.5	2.4	2.9	3.8	3.3	2.3
X_{12}	177	151	127	102	188	208	221
X_{13}	140	69	157	0	242	147	143
X_{14}	56	69	45	100	44	59	61
X_{15}	27	22	18	12	35	20	23
X_{16}	23	9	22	11	26	21	31
X_{17}	14	10	8	6	10	9	13
X_{18}	12	3	14	0	12	11	14
X_{19}	52	46	44	50	29	45	57
X_{20}	52	33	64	0	46	52	45
X_{21}	6.6	6.9	7.1	8.5	5.4	10.4	9.6
X_{22}	6.1	7.7	7.1	0	9.3	7	4.6
X_{23}	12.6	15.1	15.9	17	18.8	23.1	17
X_{24}	11.7	23	11.2	0	20.2	13.4	10.2
X_{25}	27.2	42.8	24.7	30	24.3	22	36.7
X_{26}	34.3	24.3	21.5	33.3	30.5	27.8	23.5
X_{27}	32.0	30	33	36.8	36.8	30	27.6
X_{28}	25.8	32.2	26.5	39.1	27	41.5	39.9
X_{29}	1	2.5	4	4.5	0	4.3	6.8
X_{30}	4.6	5.6	1.4	0	7	1.5	2.5
X_{31}	3	2	1	5	2	3	3
X_{32}	3	3	1	1	3	2	1
X_{33}	0	0	0	0	2	0	1